Power Plant Repowering as a Strategy for Reducing Cooling Water Consumption at Existing Electric Generating Facilities

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The Issue

- Converting from a once-through to a closed-loop cooling system can produce significant reductions in water usage and provide environmental benefits.
- However, this conversion also can have negative impacts on power plant performance and costs.
- The actual cost and performance impacts of converting to a closed-loop cooling system depend on plant-specific equipment and design features.
- The magnitude of these impacts also depend on whether the new closed-loop system will have wet, hybrid or dry cooling towers.

Potential Cost and Performance Impacts of a Conversion to a Closed-Cycle Cooling System

- Capital investment for adding a cooling tower and modifying pump, piping and, perhaps, the existing condenser.
- Slightly higher O&M costs - closed-loop cooling systems have additional equipment that requires maintenance and specialty chemical costs for water treatment systems.
- Lost plant output (both MW and MWh) because more power is needed on-site to operate pumps and the fans in mechanical draft cooling towers.
- Additional fuel costs – plants with closed-loop cooling systems incur efficiency losses compared with once-through cooling systems.
- The potential for lost plant output if capacity must be derated during hottest and most humid periods of the year.

A Possible Alternative to Avoid these Potential Negative Impacts

- Repower the existing power plant at the same time that the cooling system is converted to a closed-loop.
- Repowering means replacing the plant’s old, inefficient and polluting equipment with a newer combined cycle unit.
- Repowering can be done in at least two ways.
  - by actually rebuilding and replacing part or all of an existing plant
  - by closing down an existing power plant, building a new unit next to it and reusing the existing transmission and fuel facilities.

Environmental Benefits of Repowering

- Repowering an older plant can include conversion from once-through to closed-cycle cooling. Cooling water intake and fish and aquatic organism impacts can be reduced by up to 98 percent.
- Repowering an older plant also usually leads to large reductions in NO_x and SO_2 emissions.
- Repowering involves reuse of an existing industrial site instead of a new greenfield site.

Economic and Reliability Benefits of Repowering

- Lower plant operating and maintenance costs
- Improved plant availability
- Improved plant efficiency (e.g. heat rate reductions from 10,600 BTU/KWh to about 7,000 BTU/KWh)
- Increased plant capacity and generation
- Although more capital intensive, repowering can make conversion to a closed-cycle cooling system more attractive from an economic point-of-view

Repowering is becoming a common practice around the U.S.

- Power plants have been repowered or are scheduled to be repowered in many states including Massachusetts, New Jersey, New York, Minnesota, Ohio, South Carolina, Kansas, Wisconsin Oklahoma, Texas, and Illinois.

Current Repowering Projects in New York State

- Bethlehem Energy Center on the Hudson River outside Albany
- East River Repowering Project on the East River in New York City
- Astoria Repowering Project on the East River in New York City
- Each of these projects is projected to have significantly lower heat rates (be more efficient) than the units being replaced and, consequently, will have substantially higher capacity factors. Each project also will have dramatically reduced water use and air emissions.

Bethlehem Energy Center

- Will replace the existing 400 MW Albany Steam Station with a new 750 MW combined-cycle facility.
- The boilers, turbines and generators from the existing facility will be retired in place.
- New facility will employ closed-loop cooling system with hybrid mechanical draft cooling towers.
- Closed-loop system will reduce the intake of Hudson River water by 98 to 99 percent, compared to the existing Albany Steam Station -- from approximately 500 million gallons per day (“gpd”) to an average of 4.72 million gpd, 8.53 million gpd maximum.

East River Repowering Project

- Will add two combustion turbine generators and steam production equipment in unused space within the existing East River Generating Station. This will enable Con Edison to retire its existing Waterside plant.
- Will provide 360 MW of electric generating capacity, an increase of 200 MW over the existing Waterside plant.
- Steam will be sold into Con Edison's steam system.
- New facility will not draw water from the Hudson River.

Astoria Repowering Project

- Would replace four existing boilers with six combined-cycle gas turbine assemblies.
- Would increase the Astoria Generating Station’s capacity from 1,254 MW to 1,816 MW.
- Would include plume-abated mechanical draft wet cooling towers and a closed-loop circulating system.
- Would reduce the amount of water drawn from the East River by over 97%, from 865,000 gpm, at present, to 24,000 gpm, during periods of peak usage.

Hypothetical Example for Illustrative Purposes

- Hypothetical repowering or retrofit of one of the existing units at the Bowline Station in the Hudson River Valley.
- In a repowering scenario, one of the existing 621 MW units at the facility would be replaced by a new 750 MW combined-cycle unit.
- Bowline Unit 1 used, on average, 99.5 billion gallons of river water each year during the period 1996-2000. Bowline Unit 2 used 48.6 billion gallons of river water each year.
- Either repowering or retrofitting one of the existing Bowline units to a closed-loop cooling system will reduce its water usage by 97 percent or more.

Sources for Economic Assumptions

- Actual plant performance from 1996 through 2000
- The December 1999 Draft Environmental Impact Statement for the Renewal of the SPDES Permits for Roseton Units 1 and 2, Indian Point Units 2 and 3, and Bowline Point Units 1 and 2.
- New York Independent System Operator projections of future combined-cycle plant operating costs and performance.
- Synapse modeling of the New York State electric system.

Key Assumptions

- Cost of converting one of the Bowline Units to a closed-loop cooling system - $59 million.
- Increased O&M from the conversion – approximately $350,000 per year.
- Lost output following conversion - 17 MW in summer, 9 MW in the winter.
- Cost of new 750 MW combined-cycle unit -- $400 to $500 million.
- Heat rate of existing unit – 10,600 BTU/KWh
- Heat rate of new combined cycle unit – 7,000 BTU/KWh.

Results

- The average cost of operating a repowered Bowline Unit in 2008 (fuel and variable non-fuel O&M) would be about $33/MWh.
- The average cost of operating a Bowline Unit in 2008 after retrofit to closed-loop cooling system (fuel and variable O&M) would be about $36.50/MWh.
- Both of these average operating costs would be below projected peak and off-peak energy prices in the Hudson Valley and New York in 2008:
  - Hudson Valley – peak hours - $47/MWh
  - Hudson Valley – non-peak hours - $37.30/MWh
  - New York City – peak hours -$57.17/MWh
  - New York City – non-peak hours - $38.44/MWh

Results

- Consequently, in repowering alternative sales of energy from the repowered Bowline Unit during both non-peak and peak hours would not only cover fuel and variable non-fuel O&M costs but would include a substantial contribution to the recovery of and a return on invested capital.
- Additional revenues in both repowering and retrofit alternatives also would be earned from the sale of capacity and reserves from the unit in the New York State wholesale markets.
- The lower heat rate for the repowered unit would result in a significantly higher capacity factor – i.e., 60 to 85 percent, versus 30 percent for the retrofit unit. The repowered unit also would have 750 MW of capacity vs. the approximate 600-610 MW of capacity that would be available from the retrofit unit.

Additional Flow Reduction Benefits

- Due to its significantly lower heat rate, the repowered unit would displace electricity that would otherwise be generated at older, less efficient power plants along the same or other waterways.
- For example, Reliant has projected that, when completed, its repowered Astoria facility will displace production from less-efficient, generating facilities in New York City, including the Ravenswood and Arthur Kill plants.
- By reducing the output from older, less efficient units, a repowering could reduce water usage at those units. But only if those facilities do not have fixed speed pumps.
- If the goal is to maximize the reduction in water usage at existing power plants, a strategy should be developed to encourage or require the installation of variable speed pumps at all facilities that are not being repowered or converted to closed-loop cooling systems.

Benefits and Disadvantages of Repowering vs. Retrofitting to a Closed-Loop Cooling System

- Benefits
  - Lower operating costs (fuel and variable O&M)
  - Significantly lower heat rate
  - Additional plant capacity
  - Significantly higher generation (MWh)
  - Significantly lower air emissions
  - Potential economic benefits from sale of air emissions allowances allocated to the unit being repowered
  - Much longer remaining operating life (e.g., 50 years vs. 20 years for the retrofit unit)

- Disadvantages
  - Significantly higher initial capital investment